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(57) Abstract

A method for manufacturing a plastic object comprises the steps of: (a) providing an injection moulding device with a mould which comprises two mould parts which in a closed position bound a mould cavity; (b) providing foaming means for causing foaming in the mould cavity of plastic injected into the mould cavity; (c) providing blocking means for temporarily rendering the foaming means effectively inactive; (d) energizing the blocking means; (e) choosing as plastic a mixture of two plastics, which first plastic is a random plastic or mixture of plastics, with the exception of type A, and which second plastic is type A and constitutes a maximum of roughly 30 percent by mass of the mixture, wherein type A is a plastic with high melt strength compatible with the first plastic, for instance HMS PP, which is high–melt–strength polypropylene; (f) causing a formed object to cool to a chosen temperature, opening the mould cavity and removing the cooled object.

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METHOD FOR MANUFACTURING A MONOLITHIC PLASTIC OBJECT, AND AN OBJECT OBTAINED WITH THIS METHOD

The invention relates to a method for manufacturing a monolithic plastic object which is constructed as structural foam and comprises a more or less sandwich-like structure with a foam core and closed skin.

Such a method and board obtained therewith is known for instance from US-A-4 096 218.

Known from this American patent specification is a method according to which a few seconds after completion of injection of the plastic the mould cavity is enlarged in a predetermined time and in controlled manner. By making use of a foaming agent and application of gas counter pressure can thus be achieved that the foam structure is of good quality, while the skin of the obtained board has a closed and smooth structure.

According to the said American patent the mould is held for a predetermined time in its closed starting position, whereafter the mould undergoes a determined expansion in a subsequent specified period. After reaching maximum expansion cooling takes place for a time, whereafter the formed board can be removed.

Attention is also drawn to US-A-4 133 858, which deals with a related technique and wherein mention is also made of a number of possible plastics for use in the context of this technique and substances such as foaming agents for adding thereto.

Applicant's own European patent application EP-A-0 692 358 relates to a further development of the technique as described in the above stated two references. According to this patent application, opening of the mould takes place in a very well defined and controlled manner, whereby in principle a plastic board

of good quality can be obtained. The drawback of this technique however is that the various parameters involved must be controlled within very narrow limits, which cannot always be realized in practice or does not result in an optimum product or process.

Since it has been found that with the known method boards of a sufficiently high and constant quality cannot be obtained, it is an object of the invention to provide a method with which an object, for instance a board, of improved quality can be manufactured.

It has been found that with the prior art method there is only a very limited freedom to vary the relevant parameters in order to obtain objects with different compositions and dimensionings. As a result it cannot always be prevented that, where there is insufficient control or freedom of a relevant parameter, the obtained product does not comply with the required quality standards.

It is therefore an object of the invention to increase the freedom of choice and the tolerance limits of the various relevant parameters.

It is a further object of the invention to make the skin thickness better controllable and even practically fully controllable.

Yet another object of the invention is to shorten a production cycle.

Finally, it is an object of the invention to make the foam density distribution considerably better controllable than is the case with the prior art.

In respect of the above the invention provides a method for manufacturing a monolithic plastic object, for instance a board, which object comprises a sandwich-like structure with a foam core and closed skin, which method comprises the following steps, to be performed in suitable sequence, of:

(1) providing an injection moulding device with a plastic-plasticizing and injection device and a mould which comprises at least two mould parts displaceable

relative to each other by displacing means, which mould parts in a closed first extreme position bound a mould cavity connecting onto the plasticizing and injection unit and in an open second extreme position release a formed object for removal, which displacing means are adapted to move the mould parts at a chosen speed;

(2) providing foaming means for causing foaming in the mould cavity of plastic injected into the mould cavity;

(3) providing blocking means for temporarily rendering the foaming means effectively inactive, for instance gas feed means for feeding gas under pressure to the mould cavity;

(4) energizing the blocking means;

(5) energizing the plasticizing and injection unit in the first extreme position of the mould in order to inject heated plastic into the mould cavity, which plastic is a mixture of two plastics, which first plastic is a random plastic or mixture of plastics, with the exception of type A, and which second plastic is type A and constitutes a maximum of 20 percent by mass of the mixture, wherein type A is a plastic with high melt strength compatible with the first plastic, for instance HMS PP, which is high-melt-strength polypropylene, which is obtained by subjecting polypropylene to an electron bombardment or electron beams, to chemical modification or direct polymerization;

(6) ending the energizing of the blocking means;

(7) ending the energizing of the plasticizing and injection unit;

(8) energizing the displacing means such that the mould parts move apart in accordance with a chosen velocity progression; and

(9) causing the thus formed object to cool to a chosen temperature, fully opening the mould cavity and removing the cooled object.

By making the foam density distribution and the skin thickness adjustable according to the invention, mechanical parameters have become adjustable and controllable. This relates for instance to the stiffness modulus, which is adjustable in a substantial range, in addition to the suitability of the material to accommodate elements with screw thread. This relates on the one hand to the adhesion and on the other to the pull-out force.

Use of the invention creates the possibility of applying very small initial wall thicknesses, for instance 3-6 mm instead of the wall thickness of for instance 6-10 mm, which is described among others in applicant's said patent application EP-A-0 692 358.

In addition, production of objects with greater wall thicknesses can be easily realized in economic manner according to the invention.

Tests have shown that with the invention a cycle time is possible with a reduction of more than 30% of the total cooling time.

Attention is drawn to the fact that, in contrast to the stated prior art, the invention is not limited to application of the so-called gas counter pressure with which foaming of the injected plastic in the mould cavity can be temporarily discontinued.

The dependent claims 2-14 relate to specific embodiments of the method according to the invention. It is noted that the mentioned materials and substances are only summarized by way of example without any limitative significance.

The invention relates to specific application of the second plastic of the described type A consisting of a material with high melt strength, for instance polypropylene which has been subjected to an electron bombardment, whereby a change in the material has occurred so that the per se known HMS PP is obtained, which is high-melt-strength polypropylene. Such a material can be compared to "chewing gum". It is a

material which displays a strengthening behaviour when the melt is extended or stretched uni-axially or biaxially. Stabilizing occurs due to the strong increase in the stretch viscosity of thin, extending parts of the melt. The material has been per se known for a number of years and is applied as bulk material in extruder foams. Examples of such materials are PF633 from Montell Polyolefins, which has an MFI (Melt Flow Index) of 5.5 grams per 10 minutes at a temperature of 230■C, 2.16 kg. Another material is PF814 from the same manufacturer. This material is recommended by the manufacturer for use in foam products of low density. It has an MFI of 3.0 grams per 10 minutes at a temperature of 230■C, 2.16 kg.

In addition to the above mentioned high-melt-strength polypropylene, other suitable materials with high melt strength can also be used. This relates to materials with High Melt Strength behaviour. The additive is compatible with the bulk polymer(s) and is characterized by the occurrence of a relevant increase in the stretch viscosity during uni-axial or biaxial stretching of the melt. The increase in stretch viscosity at low constant shear rate (<5 s^{-1}) is much larger (30% or more) in the time during the stretching than the increase in stretch viscosity of the base polymer(s).

For a definition of stretch viscosity (German: Dehnungsviskosität) reference can be made to the literature, for instance Munstedt, H.J., Reology (1979) 23, p.421). For measurements on HMS reference can be made to E.M. Philips et al: Polypropylen mit hoher Schmelzstabilität, Kunststoffe 82, 1992.

With respect to the manner in which for instance HMS PP can be obtained, it is noted that different options exist for this purpose. PP can for instance be subjected to an electron bombardment. Alternatively, chemical modification or direct polymerization of polypropylene can be envisaged.

In claim 6 are mentioned several materials which are considered suitable as first plastic. Addition

of a polyolefin or a mixture of polyolefins is at this moment being envisaged for use of HMS PP.

As stated above, the invention in its general form relates to the addition of plastic type A up to a total in the mixture of a maximum of roughly 30 percent by mass. When a larger quantity is used, the drawback is encountered that the price of the plastic objects obtained becomes unacceptably high, since HMS PP for instance is a relatively expensive raw material. It has further been found that above the stated limit of about 30 percent by mass the activity of HMS PP decreases.

The method preferably has the special feature that a maximum of about 30 percent by mass of type A is present in the mixture.

A preferred embodiment of the method has the feature that about 4-6 percent by mass of type A is present in the mixture. At values below the range specified here the influence of HMS PP is found to be too limited to be deemed useful technically and economically.

The invention further relates to a monolithic plastic object obtained with a method of the above described type specified in the claims.

During the manufacture such an object can also be formed integrally in per se known manner with a (decorative) foil, a cloth or other cover material.

The invention also relates to the use of a plastic with high melt strength, for instance HMS PP (high-melt-strength polypropylene obtained by subjecting polypropylene to an electron bombardment or electron beams, to chemical modification or direct polymerization) as component in a plastic mixture with a proportion of a maximum of 30 percent by mass, in accordance with the above described methods.

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CLAIMS

1. Method for manufacturing a monolithic plastic object, for instance a board, which object comprises a sandwich-like structure with a foam core and closed skin, which method comprises the following steps, to be performed in suitable sequence, of:

(1) providing an injection moulding device with a plastic-plasticizing and injection device and a mould which comprises at least two mould parts displaceable relative to each other by displacing means, which mould parts in a closed first extreme position bound a mould cavity connecting onto the plasticizing and injection unit and in an open second extreme position release a formed object for removal, which displacing means are adapted to move the mould parts at a chosen speed;

(2) providing foaming means for causing foaming in the mould cavity of plastic injected into the mould cavity;

(3) providing blocking means for temporarily rendering the foaming means effectively inactive, for instance gas feed means for feeding gas under pressure to the mould cavity;

(4) energizing the blocking means;

(5) energizing the plasticizing and injection unit in the first extreme position of the mould in order to inject heated plastic into the mould cavity, which plastic is a mixture of two plastics, which first plastic is a random plastic or mixture of plastics, with the exception of type A, and which second plastic is type A and constitutes a maximum of 20 percent by mass of the mixture, wherein type A is a plastic with high melt strength compatible with the first plastic, for instance HMS PP, which is high-melt-strength polypropylene, which is obtained by subjecting polypropylene to an electron

bombardment or electron beams, to chemical modification or direct polymerization;

(6) ending the energizing of the blocking means;

(7) ending the energizing of the plasticizing and injection unit;

(8) energizing the displacing means such that the mould parts move apart in accordance with a chosen velocity progression; and

(9) causing the thus formed object to cool to a chosen temperature, fully opening the mould cavity and removing the cooled object.

2. Method as claimed in claim 1, wherein a maximum of 10 percent by mass of type A is present in the mixture.

3. Method as claimed in claim 2, wherein roughly 3-7 and preferably 4-6 percent by mass of type A are present in the mixture.

4. Method as claimed in claim 1, wherein the plastic is thermoplastic.

5. Method as claimed in claim 1, wherein the plastic contains at least one polymer.

6. Method as claimed in claim 1, wherein the plastic contains a polyolefin, vinyl polymer or styrene, for instance LDPE, HDPE, PP, EVA, PVC, PS, ABS, PPO.

7. Method as claimed in claim 1, wherein the plastic contains a homopolymer.

8. Method as claimed in claim 1, wherein the plastic contains a copolymer.

9. Method as claimed in claim 1, wherein to the plastic is added a filler (such as limestone, talcum, glass fibres), an additive (such as TiO_2, $BaSO_3$, $BaSO_4$), a stabilizer, a colouring agent or the like.

10. Method as claimed in claim 1, wherein to the plastic is added a chemical foaming agent (such as hydrocerol LC, hydrocerol compound, 5-phenyltetrazole, azodicarbonamide, $NaHCO_3$, $(NH_4)_2CO_3$, $(NH_4)HCO_3$), sulphohydrazides, triazine compounds, toluene-

sulphosemicarbazide and/or a physical foaming agent (such as N_2, H_2O, isobutane).

11. Method as claimed in claim 1, wherein the mould cavity has a form such that the object is a board and has a non-round shape.

12. Method as claimed in claim 1, wherein the obtained object is a board and has a peripheral edge zone of a shape and dimensions preselected as desired, for instance has a bent edge.

13. Method as claimed in claim 1, wherein prior to injection of plasticized plastic into the mould cavity gas, for example nitrogen or optionally conditioned air, is admitted under pressure into the mould cavity.

14. Method as claimed in claim 1, wherein the method is performed such that the obtained object fulfills set requirements relating to thermal insulation, acoustic insulation, mechanical strength, vibration- and/or shock-damping properties, required skin thickness, required pull-out force for screws or inserts and required bending stiffness of the board.

15. Monolithic plastic object obtained with a method as claimed in any of the foregoing claims.

16. Use of a plastic with high melt strength, for instance HMS PP (high-melt-strength polypropylene obtained by subjecting polypropylene to an electron bombardment or electron beams, to chemical modification or direct polymerization) as component in a plastic mixture with a proportion of a maximum of 30 percent by mass, for use of a method as claimed in any of the claims 1-14.

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INTERNATIONAL SEARCH REPORT

Int. Ional Application No
PCT/NL 97/00637

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 B29C44/10 B29C44/14

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 B29C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0 450 342 A (AUSIMONT SPA) 9 October 1991 see abstract see page 3, line 15 - page 4, line 13 see page 4, line 23 - line 54 see page 5, line 3 - line 35 see page 6, line 15 - line 20 see claims	1-10,15, 16
X	EP 0 692 358 A (CORELL RESIN TECHNOLOGY B V) 17 January 1996 see the whole document	1-15

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[X] Further documents are listed in the continuation of box C.

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